

CLAIMS

Therefore, having thus described the invention, at least the following is claimed:

- 1 1. A method for back-side-of-die, through-wafer guided-wave clock distribution,
2 comprising:
3 providing an optical clock signal and an integrated circuit device, wherein
4 the integrated circuit device includes a device substrate and the optical clock
5 signal has a wavelength so that the optical clock signal can pass through the
6 device substrate;
7 distributing the optical clock signal at a global level of the integrated
8 circuit device through a uniform, unfocused guided-wave progression; and
9 propagating the optical clock signal vertically, through the device
10 substrate directly to a local level of the integrated circuit device.

- 1 2. A method for unfocused guided-wave clock distribution, comprising:
- 2 providing an optical clock signal and an integrated circuit device, wherein
- 3 the integrated circuit device includes a device substrate and the optical clock
- 4 signal has a wavelength so that the optical clock signal can pass through the
- 5 device substrate;
- 6 propagating the optical clock signal vertically, through the device
- 7 substrate, from the front-side of the integrated circuit device to the back-side of
- 8 the integrated circuit device;
- 9 distributing the optical clock signal from a vertical to horizontal
- 10 orientation on the back-side of the integrated circuit device;
- 11 distributing the optical clock signal in a plurality of horizontal directions
- 12 on the back-side of the integrated circuit device through a uniform, unfocused
- 13 guided-wave progression;
- 14 distributing the optical clock signal from a horizontal to vertical
- 15 orientation on the back-side of the integrated circuit device; and
- 16 propagating the optical clock signal vertically, back through the integrated
- 17 circuit device substrate, from the back-side of the integrated circuit device to the
- 18 chip-level of the integrated circuit device.

1 3. The method of claim 2, further comprising:

2 communicating the optical clock signal from an on-chip optical source to
3 the back-side of the integrated circuit device by propagating the optical clock
4 signal vertically, through the device substrate.

1 4. The method of claim 2, further comprising:

2 capturing the secondary optical reflection during distribution of the optical
3 clock signal from a vertical to horizontal orientation on the back-side of the
4 integrated circuit device;

5 capturing the secondary optical reflection during distribution of the optical
6 clock signal in a plurality of directions on the back-side of the integrated circuit
7 device by a uniform, unfocused guided-wave progression; and

8 capturing of secondary optical reflection during distribution of the optical
9 clock signal from a horizontal to vertical orientation on the back-side of the
10 integrated circuit device.

1 5. The method of claim 2, further comprising:

2 distributing the optical clock signal through a printed wiring board
3 substrate connected to the integrated circuit device; and

4 out-coupling of the optical clock signal from the printed wiring board
5 substrate.

- 1 6. The method of claim 2, further comprising:
2 coupling of the optical clock signal from a printed wiring board substrate
3 connected to the integrated circuit device to a package layer in the integrated
4 circuit device;
5 distributing the optical clock signal through the package layer; and
6 out-coupling of the optical clock signal from the package layer to the
7 back-side of the integrated circuit device.
- 1 7. The method of claim 2, further comprising:
2 generating the optical clock signal on the integrated circuit device.
- 1 8. The method of claim 2, further comprising:
2 communicating the optical clock signal from an off-chip optical source to
3 the back-side of the integrated circuit device by propagating the optical clock
4 signal vertically, through the device substrate.
- 1 9. The method of claim 8, further comprising:
2 routing the optical clock signal to at least one point of fanout before
3 directly communicating the optical clock signal to the back-side of the integrated
4 circuit device.

- 1 10. The method of claim 8, further comprising:
2 routing the optical clock signal to at least one point of fanout; and
3 communicating with a fixed-fanout on-chip distribution, with each point
4 of fanout communicating the optical clock signal to the back-side of the integrated
5 circuit.
- 1 11. A structure for unfocused guided-wave optical clock distribution, comprising:
2 an integrated circuit device;
3 a first cladding layer disposed on the back-side of the integrated circuit
4 device; and
5 a core layer disposed on the first cladding layer, wherein the core layer
6 includes at least one vertical-to-horizontal input diffraction grating, at least one
7 horizontal-to-horizontal diffraction grating, and at least one horizontal-to-vertical
8 output diffraction grating.
- 1 12. The structure of claim 11, wherein the first cladding layer is a write-wavelength
2 vertical reflection absorption layer.
- 1 13. The structure of claim 11, further comprising:
2 a second cladding layer adjacent to the core layer.
- 1 14. The structure of claim 11, further comprising:
2 a horizontal reflection absorption layer adjacent to the core layer.

- 1 15. The structure of claim 11, further comprising:
2 at least one chip-level detector on the integrated circuit device.
- 1 16. The structure of claim 11, further comprising:
2 at least one chip-level optical via; and
3 a printed wiring board substrate connected to the integrated circuit device.
- 1 17. The structure of claim 16, wherein the at least one optical via is a dielectric filled
2 through-wafer via.
- 1 18. The structure of claim 11, further comprising:
2 at least one chip-level optical source.
- 1 19. A structure for unfocused guided-wave optical clock distribution, comprising:
2 an integrated circuit device;
3 a first cladding layer disposed on the back-side of the integrated circuit
4 device, wherein the first cladding layer includes at least one vertical-to-horizontal
5 input diffraction grating, at least one horizontal-to-horizontal diffraction grating,
6 and at least one horizontal-to-vertical output diffraction grating; and
7 a core layer disposed on the first cladding layer.

- 1 20. The structure of claim 19, wherein the at least one vertical-to-horizontal input
2 diffraction grating is a multiplexed grating and the at least one horizontal-to-
3 vertical output diffraction grating is a multiplexed grating.
- 1 21. The structure of claim 19, wherein the first cladding layer is comprised of a
2 grating selected from volume gratings, surface-relief gratings, multiplexed
3 volume gratings, double-sided surface relief gratings, and combinations thereof.
- 1 22. A structure for unfocused guided-wave optical clock distribution, comprising:
2 an integrated circuit device;
3 a first cladding layer disposed on the back-side of the integrated circuit
4 device;
5 a core layer disposed on the first cladding layer, and
6 a second cladding layer disposed on the core layer, wherein the second
7 cladding layer includes at least one vertical-to-horizontal input diffraction grating,
8 at least one horizontal-to-horizontal diffraction grating, and at least one
9 horizontal-to-vertical output diffraction grating.
- 1 23. The structure of claim 22, further comprising:
2 a vertical reflection absorption layer adjacent to the second cladding layer.
- 1 24. The structure of claim 23, wherein the vertical reflection absorption layer absorbs
2 at an optical wavelength which is transparent to the device substrate.

1 25. A device, comprising:

2 a structure having a core layer disposed on the back-side of the structure,
3 at least one vertical-to-horizontal input diffraction grating within the core layer, at
4 least one horizontal-to-horizontal diffraction grating within the core layer, at least
5 one horizontal-to-vertical diffraction output grating within the core layer, and at
6 least one cladding layer engaging the core layer, wherein an optical clock signal is
7 propagated vertically through the structure substrate to the core layer, into the at
8 least one vertical-to-horizontal input diffraction grating and is then distributed
9 laterally through the at least one horizontal-to-horizontal diffraction grating to the
10 at least one horizontal-to-vertical output diffraction grating, which distributes the
11 optical clock signal vertically back through the structure substrate.

1 26. A device of claim 25, wherein the structure for optical clock distribution is
2 included in a microelectronic device.

1 27. A device of claim 25, wherein the structure for optical clock distribution is
2 included in an integrated optical device

- 1 28. A method for fabricating a device having unfocused guided-wave optical clock
2 distribution comprising:
3 providing a substrate having a first cladding layer disposed thereon;
4 disposing a core layer on the first cladding layer;
5 forming vertical-to-horizontal input diffraction gratings within the core
6 layer;
7 forming horizontal-to-horizontal diffraction gratings within the core layer;
8 and
9 forming horizontal-to-vertical output diffraction gratings within the core
10 layer.
- 1 29. The method of claim 28, further comprising:
2 etching away a portion of the core layer at the edges of the substrate and
3 replacing it with a horizontal reflection absorption layer.
- 1 30. The method of claim 28, wherein the device includes at least one detector.
- 1 31. The method of claim 28, wherein the device includes an optical via and further
2 comprising a packaging layer and a printed wiring board substrate.
- 1 32. The method of claim 28, wherein the device includes an optical source.

1 33. The method of claim 28, further comprising:
2 disposing a second cladding layer on the core layer.

1 34. The method of claim 33, further comprising:
2 disposing a vertical reflection absorption layer on the second cladding
3 layer.

1 35. A method for fabricating a device having unfocused guided-wave optical clock
2 distribution comprising:
3 providing a substrate having a first cladding layer disposed thereon;
4 forming vertical-to-horizontal input diffraction gratings within the first
5 cladding layer;
6 forming horizontal-to-horizontal diffraction gratings within the first
7 cladding layer;
8 forming horizontal-to-vertical output diffraction gratings within the first
9 cladding layer; and
10 disposing a core layer on the first cladding layer.

- 1 36. A method for fabricating a device having unfocused guided-wave optical clock
2 distribution comprising:
3 providing a substrate having a first cladding layer disposed thereon;
4 disposing a core layer on the first cladding layer;
5 disposing a second cladding layer on the first cladding layer;
6 forming vertical-to-horizontal input diffraction gratings within the second
7 cladding layer;
8 forming horizontal-to-horizontal diffraction gratings within the second
9 cladding layer; and
10 forming horizontal-to-vertical output diffraction gratings within the
11 second cladding layer.
- 1 37. A system for fabricating a device having back-side-of-die, through-wafer optical
2 clock distribution comprising:
3 means for providing a substrate having a first cladding layer disposed
4 thereon;
5 means for disposing an core layer on the first cladding layer;
6 means for forming vertical-to-horizontal input diffraction gratings within
7 the core layer;
8 means for forming horizontal-to-horizontal diffraction gratings within the
9 core layer; and
10 means for forming horizontal-to-vertical output diffraction gratings within
11 the core layer.